

Life-Cycle Eco-Services for Sustainability

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Abstract

The paper addresses the sustainable growth, or even better: 'sustainability' as a challenge for tomorrow, to assure progress continuation. From engineering viewpoints, the bet has to be accepted, and the 'service economy' provides valuable hints, affixing chances, with innovative worth. Pertinent details are specified, with links to the net concern deployments. The paper gave a survey and some genuine ideas to understand some crucial problems of mankind, which were out of scope for several hundreds of years and became important – at least some people started to understand and explain – only in the second part of the previous century, namely problems of ecology, of environment, of expectable energy and material shortages, including drinking water, which all together led to the acceptance of sustainable growth and then of sustainability. Sustainability may mean our survival from technical and social point of view as well. The importance and management of services – besides the production – will be discussed in details. Personal and company level issues will be analysed, as well as international and European Union level problems and solution efforts. Life-cycle management of traditional and extended (virtual) organizations, and the tangible and intangible properties and views of all types of objects were discussed, too.

Keywords

Sustainability; Life-Cycle; Virtual Organization; Services

Introduction

The growth sustainability is impending threat of the ecology globalisation, showing the over-depletion and over-pollution trends of the current industrialism. The analyses suggested that the civilisation continuance is option or bet, to be grounded on radical changes, i.e., on the 'cognitive revolution', bringing the intangibles to critical position for the prosperity, rooted in the 'anthropic principle', which states that the man intervention allows creating artificial settings, granting 'value added' out of the original wilderness.

See (Abele, 2005), (Baskin, 1999), (Charbonneau, 2006), (Gou, 2009), (Hawken, 1999), (Hodgson, 2010),

(Michelini, 2000), (Warren F. R., 2012), (Wills B., 2009), Zuber-Skerrit O., 1991).

The 'civilisation' is rooted in series of intentional alterations of the surrounds, promoting artificial shifts to men's steered improvements. These particularities are instigated by the relational 'intelligence' singularity, entailing modifications conceived in the abstract mind worlds and (actually) verified useful, once transferred into operative plans. The mind world is origin of 'knowledge': its effectiveness exists if coding, sharing and storing abilities are enabled, ending in determined 'culture' and 'ethics' artefacts. For details consult (Lacy S., 2011), (Low L., 2004), (Macarthur, 2010), (Michelini, 2012), (Vinig G.T., 2005), (Wassermann O., 2001), (Wilkinson R., 2009), (Woods, 2006), (Xie M., 2012), (Yergin D., 2011). The 'civilisation' alterations track combined issues, discriminating:

- the interpersonal relationships, inventing effective 'collective orders';
- the natural resource exploitation, discerning 'technology revolutions'.

The alterations are thought improvements, since the life-quality increases, compared to wildlife conditions. The development is believed entailing man inventions, which create value added by purposeful alterations, named 'human', 'material', 'financial' and 'technical' capitals. The ecology has recently obliged to look at the utilisation of earth resources, debased in wastes, and making unsafe the industrialism. The investigation reviews some basic topics, to suggest changeovers, typically, addressing the 'service economy', with twofold purposes: to provide monitoring aids and to explore recovery/remediation chances.

The 'human capital' plays constituent and instrument roles, since the archaic social breakthroughs enabling 'collective orders', by group selection, or, lately, by nation-state differential effectiveness, until, desirably, by knowledge society advance. The 'natural capital' is

indispensable supply of value-added transformations and is critical datum, with the industrialism over-consumption and over-pollution. The 'natural'/'technical' capitals are artificial entries, used to depict the intangible construal of the mind worlds, supplying intangible frames, to make manifest the administrative, economic, political and social advances of the timely qualified 'collective orders'.

The 'civilisation' peculiarities have intangible trait, but need tangible provisions. The 'cognitive revolution' moves from knowledge society advance, using robot age innovation, instigating 'to de-materialise' and 'to re-materialise' processes with source restoring and biosphere reclamation purposes, rooted in artificial life-and-intelligence chances. This is bet, whose feasibility runs not only into technology confronts, but as well into socio-political defies.

The 'anthropic principle' says that the exam shall be tackled, as this is man's task or mission. It, further, tells how our knowledge imposes rules, which select, out of many possible environments, those laws, leading to the 'life' and 'intelligence'. The 'civilisation' becomes tautological upshot, having the holistic reading of the quantum dynamics relating the general relativity. The quizzical hypothesis deserves notice, even if lots of doubts are present in the amazing cosmologic backdrop. Then, the relational 'intelligence' plays the role of constituent enabler, along with evolution paths, towards the hoped progress. If the sustainable growth is the new threat, the 'cognitive revolution' is, with a bit of luck, winning defy and, perhaps, much more!

Progress and Industrialism

The industrial economy is based on the effectiveness in transforming raw materials into useful goods for the satisfaction of wide amounts of customers; the amazing productivity has a drawback, in the change of natural resources into waste and pollution, without allowing natural recovering (even while conceivable, out of the relentless entropy decay of the entire physical world). In science and technology domains, the urgency of the 'sustainable' growth is emerging as trans-disciplinary demand, to assure less eco-penalising wealth creation, so to manage the over-consumption and over-pollution, in view of the over-population increase.

In that context, the 'service science' plays fundamental role, with, basically, the twin duty of qualifying and expanding the value added in intangibles, and of

supporting and provisioning the knowledge for the tangibles recovery. Truly, the 'servicing infrastructure', through world-wide-web and net-concerns, is winning chance to enable the eco-consistent behaviours according to the two paradigms, as in (Agar, 2012), (Antonelli, 2008), (Bhide, 2008), (Carlson, 2010), (Dym, 2010), (Friedman, 2009), (Hilaire-Pérez, 2003), (Michelini, 2008), (Wohlgemuth V., 2009):

- to de-materialise, by trading 'functions' that replace the good ownership, still enjoying the annexed utility, reliably supplied at the point-of-service;
- to re-materialise, by contributing the 'recovery' instruments to the reverse logistics and to the biomimicry resources reinstatement processes.

The 'service infrastructures' are essential fallouts of the knowledge entrepreneurship, when the value chain is especially turned to the information and communication technologies and to the connected supporting know-how, while the material supply chain is reduced to become the auxiliary complement. The opportunity exists, with noteworthy achievements also in the past, in the delivering of 'mobility' or 'computation', to replace the car-fleet or the mainframes ownership. With the 'service science' for the growth sustainability, the idea is to aim at the structured approach, to identifying, analysing and solving the business-related issues of clients' needs satisfaction, according to the quoted to de-materialise and to re-materialise paradigms, with pervasive resort to ambient intelligence, namely, to ubiquitous communication and computing aids. More in (Fukuyama, 2011), (Michelini, 1976), (Targowski A., 2008), (Thursby M., 2008), (Tinaglia I., 2005), (van Johnston, 2010), (Vergne P., 2012), (Wickramasinge, 2007), (Zarnekow, 2006), and (Zurawski, 2007).

Intangibles Driven Supply Chain

Within the service sector, several academic disciplines exist that shall be simultaneously considered in order to achieve optimal results, e.g., operations management, marketing policies, human resource programming, information technology, design innovation, and so on. The sustainable growth, today, really represents the enabling spur, through the transparent ruling and acknowledgement of the eco-impact, out-coming from the tangibles supply chains. Basically, all who are interested in sustainable growth require deep understanding of the Service Science, and advanced exploration on how the servicing infrastructures would modify the earlier manufacture organisations, to put in the market the enhanced

'products-services' (say: 'extended artefacts'), consistent with more eco-conservative behaviours.

The idea of the prospected changeovers is to look after new operation infrastructures, shaped into 'extended enterprises' with suitably configured service orientation, either on 'virtual organisations', with duty-driven ephemeral architectures, exploiting the facilities/ functions trading, through net-concerns and special purpose brokerage aids See (Lin J.Y., 2012), (Olhagher, 2007), (Otto K.N., 2001), (Phahalad C.K., 2008), (Preston R., 2012), (Pries, 2009), (Putnik, 2007), (Victor D., 2011), (Wheeler, 2012), (Zhuge H., 2012).

The Product-service Organisation

The attention to service engineering comes out almost obviously as technology-driven opportunity, when one perceives that ICT is enabling instrument, to establish the information value chains for the product lifecycle management. Indeed, the environment protection lumps producers (which profit of the natural resources, by transforming them into products) and users (which enjoy of the deliveries, to satisfy individual needs), into the unified consumers side (which take direct benefits, and scatter the eco-impacts over guiltless people and future generations), and establishes sets of behavioural constraints, progressively expanding the construction files to include, since the design and development stage of a new item to be put in the market, to include the lifecycle accountability, Fig. 1, of the whole supply chain.

- the on-duty operation specification,
- the on-duty operation specification, through fitting *product lifecycle manager*(PLM);
- the conformance assessment setting, via suitable *service engineering*(SE) provision;
- the end-of-life recovery (reuse, recycle) duties, by the *reverse logistics*(RL) liability.

FIG. 1 DATABASE OF THE PRODUCER'S EXTENDED RESPONSIBILITY

The entrepreneurial lay-out shall evolve, extending the conventional bent onwards manufacture business, to encompass wider 'externalities', say, the PLM, the SE and the RL frames, which, one after the other, include on-duty product-data responsiveness, operation conformance assessment commitment and end-of-life call-back responsibility, as standard business requirements. The agenda evolves as for knowledge contents and as for task allocation, Fig. 2, progressive covering the obligatory eco-targets.

- from (mainly bilateral) supplier-to-customer responsiveness, with small concern on eco-consistency; at this level, appropriate PLM aids are purposely implemented, with stress on the 'product' operation life;
- through (jointly liable) consumers' commitment, to reach eco-conservativeness by voluntary agreements; at this level, advanced SE tools aim at competitiveness, focussing, e.g., on the maintenance 'service' duties;
- to (sole) manufacturers responsibility, to comply mandatory targets under environmental acts; eco-design is best-practice for the supply chains, when free take-back and enforced recovery are compulsory commissions.

FIG. 2 TOWARDS PRODUCER'S EXTENDED RESPONSIBILITY

The resulting entrepreneurial lay-out is, typically, referred as 'extended enterprise', merging, into a shared infrastructure, skills, know-how, facilities and resources, to enable co-design, co-manufacture, co-market, co-maintain, co-servicing, co-recovery, etc. efforts, to offer 'products-services' at purchaser's benefit and environment safety. The 'product-service' or 'extended artefact' is any provision joining the manufactured commodities and the enabling utilities (the artefact is any object made by man with skill, especially with a view of subsequent use).

The delivery of 'extended artefacts' is the consistent business of 'extended enterprises', in which the return on investment is achieved through 'externalities', say, through PLM-, SE- and the RL-driven duties. Today, the competitiveness turned on 'externalities' starts to be said as 'advanced' option, as the leading consumers (manufacturers) responsibility towards third people is, only, at a very early stage, and very few (far sighting) companies possess well-structured PLM and proper lifecycle assessment checks, forecast the offer, through voluntary agreements; of SE ambient intelligence for on-duty maintenance, and develop proprietary recovery policies for the already enacted mandatory targets in the RL frames. A cultural gap, possibly, exists, because the attention on 'external' functions and the provision of 'targeted' services are, by their very nature, trans-disciplinary efforts, and do not belong to the conventional domains of the manufacture processes.

The Extended/ Virtual Settings

It is time for the service science to be structured as self-

consistent sphere, because of its relevant economical fallouts as for the emerging manufacturing organisations and unified technical background of the information layouts, affecting the knowledge entrepreneurship. The anomaly of 'extended enterprise' coherent solutions, perhaps, deeply dissected in their ICT peculiarities, yet loosely enabled in the production practices, requires that, at least for a while, a bottom-up approach, entrusted from operation details, to academic envisions.

Today, net concerns and world-wide-web are standard options, with shared acceptance in the current habits; e-communication, e-banking, e-market, etc. are everyday practice, with no especial denial or remark, when operating into loose contexts, out of cast about frames. The 'extended enterprise', the other way, faces formal demands, needing to follow more conventional approach, Fig. 3, in dealing with its functional organisation.

- the partners selection: the set of actors joins for the business opportunity, but responsibility, straight away, distinguishes producers from auxiliary providers, associated stakeholders and overseeing bodies;
- the competencies build-up: the trading of facilities/functions allows making ready the proper partner, at the right time and location, whenever the specific service is requested;
- the trust enhancement: the partners' involvement requires a hierarchic setting and there is no reason to share risk and profit, out of the individual duties/incumbents;
- the teamwork development: the company-spirit is hard to establish during ephemeral collaboration; thus, the aggregation rewarding is empowered by the contribution technical appropriateness;
- the legal formation: a special-purpose extended enterprise legislation does not exist; 'consortiums' or 'joint ventures' are, possible starting references, but the situation will quickly modifies.

FIG. 3 THE EXTENDED ENTERPRISE ORGANISATION

In the meantime, the attention on technicalities suggests looking at 'virtual enterprises', say, organisations assembling the competencies build-up and assuring the 'externalities', namely, the PLM, the SE and the RL frames, each time requested by the

'extended artefact' supply, without, actually, reaching fully hierarchical structured deployment. The alternative is a factual alliance of partners, with obligations on the supply chain, at the lifecycle span, established by contractual agreements. According to the sketched formal approach, the 'virtual enterprise' setting is fostered by fitting options, Fig. 4, which shall ripen in the entrepreneurial lay-out.

- the trading of facilities/functions, to provide and manage the offers of partnership, enabling the net concern formation and up-dating, at low transaction costs and efficient legal protection;
- the integration support or broker aid, which acts, as net concern node or as external agent, for merging the demands and offers, and for assuring the on-process dynamic configurability;
- the education to virtuality, to make evident the advantages of dynamic net concerns, over static enterprise instances, when dealing with "externalities" out of the company core business.

FIG. 4 THE VIRTUAL ENTERPRISE FITTINGNESS OPTIONS

The picture is consistent with acknowledging the 'extended enterprise' lifecycle, more or less, as it is done by the 'extended artefact' lifecycle. The 'virtual enterprise' acts as a cluster of 'extended enterprises', which, each time, enables the requested competencies build-up. This suggests that the flow of the products along the manufacturing facilities characterises the traditional production processes; whereas the flow of the facilities along the product-service delivery assures competitiveness of the service-driven organisations. The market of facilities is fundamental prerequisite of the 'virtual enterprises'; the role of brokerage and fair-trade aids has to be addressed to grant, both, SE and RL effectiveness.

The Integration Choices and Prospects

The extended/virtual settings do not differ at the backing information/communication frames. The bottom-up characterisation of the net concern leads to typical features, such as the ones listed in Fig. 5.

The organisation merging develops over four different information sources: product-process-environment-enterprise, 2P2E, by the pace-wise amalgamation of functional models and performance assessments. The operation construal includes the related databases, Fig. 6.

- responsiveness: a 'virtual enterprise' to play a role in the market shall be perceived as single company, or at least, a single member of the net concern should be identified as the 'extended artefact' responsible; this might become a problem, when no significant organisational supra-structure exists;
- legal personality: in a joint venture, every partner keeps its individuality, and a legal contract cannot be concluded by the ensemble, rather by single members, jointly or separately liable; the 'consortium' somewhat modifies the situation, with, however, restrictions on the partnership flexibility;
- global liability: the net concern efficiency is expected to come out from fitting worldwide partnership, by special enhancement from close-to-market partners; the clear agreement, upon which national law governs, should not hinder the actual manufacturers (this is important for most of low-price consumables, where free take-back incumbents could completely change the international trade competition);
- ephemeral character: if strictly dependent on the business opportunities, the 'virtual enterprise' instances come and go, conflicting with the life-support of most of durables; possible remedies are: insurance partners covering the lifelong delivery; a deposit/refund scheme to grant the "future" servicing, etc.;
- supply chain visibility: this requires multiple-range accomplishments, depending on the actual net concern set-ups, amid the PLM, SE and RL 'externalities', to cover operation/withdrawal service providers, to grant front-end users and third-people safeguard, to assure eco-assessment and remediation duties, and so on.

FIG. 5 THE NET CONCERN -- FUNCTIONAL CHOICES

- the standard product data: physical representation; operation performance, quality, cost and affordability; producibility; lifecycle requirements; use and maintenance directions; dismissal instructions;
- the standard manufacturing data: materials procurement and processing, assembly and disassembly; quality testing and conformance assessment; packaging; re-manufacturing;
- the standard environment data: voluntary agreements for low pollution and high remediation; mandatory targets to rule recovery (reuse, recycle) and safe dumping;
- the standard enterprise data: business functions: trading strategies, finance and resource management, etc.; operation functions: factory and facilities management, scheduling and planning, etc..

FIG. 6 THE INTEGRATION DATABASES -- CONSISTENCY

The factual, trans-disciplinary approach leads to an integrated product-process-environment-enterprise, 2P2E, design, entailing operations in the four domains, to allow suited streamlined lifecycle assessment (SLA), of the delivery eco-consistency. The 2P2E design under SLA checks specifies the efficiently structured net concern, according to the enacted eco-targets on the four knowledge domains, Fig. 7, balancing manufacturing flow, to lifecycle and recovery demands.

The process ends, acknowledging the 'sustainable corporation', i.e., the entrepreneurial settings having inner service-oriented organisation, which assures achieving lawful eco-targets.

- product design specification, leading to (CAD, CAM, etc.) construction files, to select producibility figures, duty constraints, disposal incumbents, etc., in relation to the forecast on-duty performance;
- manufacturing process specification, leading to improve factory effectiveness by simultaneous engineering aims through product-and-process mutual betterment, by means of pace-wise upgrading;
- delivery lifecycle specification, leading to define regulation, maintenance, restoring, etc. plans, for operation within conformance-to-use, and to pre-set disposal, recovery, etc. plans, for enhanced reverse-logistics;
- entrepreneurship specification, leading to define the business policy, the productive organisation and the facilities selection, as for the most efficient inner/outer functions and services management.

FIG. 7 THE ECO-CONFORMANCE BY STRAMLINED LIFECYCLE ASSESSMENT

Service Oriented Innovation

The eco-visibility supplied by the service-oriented is enhanced by the backdrop net concerns, exploiting the extended/virtual enterprise options, basically, because of three operation sources, Fig. 8.

The 'virtual enterprise' rulers, supervised by fit govern agencies and aided by expert brokers, negotiate the configuration/ reconfiguration of the business organisation with the chosen facilities/ functions providers, so that, at each considered time, the organisation (productive set-up) assures high effectiveness to the 'product-service' delivery. At the background, spur comes from the PLM, SE and RL externalities; in the foreground, the integrated 2P2E design is enabled by

the availability of the facilities/ functions market.

- the virtual enterprise rulers or supply chain managers, which, from the devised business idea, integrate the facilities and organise the product-service delivery;
- the facilities/functions providers or (independent) actors having the skill and hardware/software potential to contribute the product-service delivery, at the given time;
- the fair-trade enablers, say, the market overseeing authorities, the brokerage supporters, etc., assuring set-up achievement and reconfiguration with responsibilities allocation.

FIG. 8 BACKDROP AIDS FOR SERVICE-ORIENTED ECO-CONSISTENCY

The sketched 'servicing infrastructures' are direct counter-part of the PLM, SE and RL 'externalities', which characterise the manufacture business to come. The required changes classify at different ranges, by respect to the traditional competencies, but, at the same time, present also different level of urgency. The PLM tools are established at the design stage, embedding special purpose checks (e.g., lifecycle eco-impact appraisal); they are an extension of the manufacturers' knowledge and not of their activity (out-of data running). The SE provision shows explicit concern of product lifecycle; the company qualifies for further jobs, not embedded in the production cycle, but exploiting the knowledge, originally developed during the design, for enhanced return by 'product-service' delivery, mainly, ruled by voluntary agreements with the buyers. The RL duties appear in the EU environmental policy as mandatory targets, with producers' responsibility; the extension is enforced, and the service delivery, if not directly ruled, is anyway performed by somebody care (and profit), as the charges are required to be allowed to put a product on the market, see (Lafley, 2013), (Marsh P., 2012), (Michelini, 2011), (Stark J., 2005), (Suh S., 2002), (Teuteberg F., 2010), (Tischner U., 2001), (Troccoli A., 2009), (Wilson, 2007), (Zatzman G., 2007). The emerging research lines are, now, exemplified, looking at standard 'product-service' management at the lifecycle and at the end-of-life stages.

The Company's Eco-qualification

The 'sustainable corporation' specification is, in any case, starting pace aiming at the legal makeover of the sustainability targets, based on the eco-soundness visibility. The qualification of a company, to become SE supporter, in view to grant the remote proactive

maintenance of the delivered items, is noteworthy goal of a 'extended enterprise', suitably structured by competencies and facilities for 'product-service' management. The approach is totally grounded on 'technical capital' tools, once the precise eco-targets are enacted over the entire global village. The depletion and pollution measurement and recording merely demands technical procedures, correctly specified and accomplished as engineering undertakings. The lifecycle conformance certification (LCC), is fair commitment, in coherence with the ecology globalisation. The corporation setting ought to programme manufacturing plans, in which the entire supplied products-services shall guarantee the befitting LCC levels, to bring out legal offers. The world over officialdom of factual 'sustainable companies' becomes suited answer; it also enjoys fitness, from economic viewpoints, meaning that the eco-consistence is mandatory prerequisite, engaging worldwide all the producers.

From merely technical standpoints, the coherent eco-design progresses from 'lifecycle inventory' with suited 'product lifecycle assessment' (PLA). The procedure entails combined tools, currently described by changeful knowledge frames, progressively modified, when the eco-consciousness increases, still, basically resorting to standardised computer aids, depending on the specialised tasks, listed in Fig. 9.

- competing product-service choice, by streamlined lifecycle assessment (SLA) tools;
- product-service delivery, trimmed by computer aided lifecycle inventory (CALI) aids;
- lifelong monitoring, diagnoses and evaluations, done by PLM, SE and RL databases;
- setting of accredited/notified certification (ANC) bodies, for supply chain lawfulness.

FIG. 9 SERVICING PREREQUISITS OF ECO-CONSISTENT SUPPLY CHAINS

The opening accomplishment starts by the 'streamlined lifecycle assessment' (SLA), using standard appraisal, capable of interfacing the 'product lifecycle assessment' (PLA), requirements with the whole PLM, SE and RL databases. One major goal is to detail the 'computer aided lifecycle inventory' (CALI) file, to accomplish the product-service delivery, unifying scope definition and impact evaluation. The standardised inventory has the scope of bonding the lifelong servicing and the supply chain specification.

The information environment of the lifecycle 'eco-consistency' design and operation of the delivered

supply chains properly shows the actual feasibility of the 'service economy' to come, based on extant technologies. The devised solution builds on bottom-up procedures, qualifying the market-operating companies bestowing lawfulness to their tangibles' manufacturing and trading. The framework is completed adding 'third party' controllers, independent on producers and users. This is 'big society' result, with resort to accredited/notified certification (ANC) bodies, which carry out devolved running, in lieu of the 'big state' handling. The setting reorganises as 'knowledge entrepreneurship', with suited operation hints, Fig. 10.

- to provide preliminary acknowledgements of these eco-conservative frameworks, in order to recognise the underlying requirements for growth enhancing;
- to suggest viable features for service engineering and inverse logistics for sustainable recovery, embedding data visibility and collaborative networked lay-outs;
- to outline the knowledge organisation of the business opportunities involving complementary stakeholders, and the enabling decision-making supports.

FIG. 10 KNOWLEDGE ORGANISATION FOR ECO-SERVICE AIMS

This leads to hypothesis that a framed model, where the eco-consistency is faced by balanced information and communication frames, is capable to manage efficient resources preservation. The list of computer tools enters the accredited/notified certification (ANC) files, to help specifying the needed addition of third-party bodies, overseeing the 'sustainable corporations' and allocating fit lawfulness to their activity.

Lifecycle/ End-of-life Recovery Management

The compulsory RL duties, enacted by the EU for the recovery of specific durables (such as ELV, end-of-life vehicles, WEEE, waste electric and electronic equipment), are instances, in which the 'service frames' have to be made ready, as inherent accomplishment of the supply chain. In these areas, the reference to 'extended artefacts' cannot be ignored; the manufacturer competitiveness will forcedly turn to integrated 2P2E design, unless, for the set of properties, fully covered by mandatory targets from existing regulations.

The ELV and WEEE cases, already, represent a very huge business that cannot be postponed, even, whether the domain producers are not yet service-

oriented, to deploy 'extended enterprises' layouts. Then, the 'virtual enterprise' by-pass ought to be investigated, at least, as temporary and local option. The ability of assembling proper net concerns, in view of a business opportunity, as above pointed out, depends on: the deployment of a facilities/functions market; the availability of integration or broker support; and the 'education to virtuality' according to effective service management rules. The three aspects deserve proper support.

The different regulation acts look after establishing eco-costs, to be included in the (tangible) goods, when brought into market. These costs need to include cleaning up, reclamation and consumption ratios, and will represent a sort of threshold tax, collected from producers/importers and dealers, to refund the supply chain burden, due to the inherent falloffs.

Some example hints are given, referring to the three phases, planned by the EU Directives, Fig. 11.

- within the production process: suitable antipollution regulations are issued at process/facility levels, and promotion of conservative design is fostered by, e.g., the Eco-design of End-use Equipment, EEE-directive, through a series of advices and warnings;
- along the supply on-duty cycle: eco-consistency figures, included in the construction file, need to be strictly followed, to reach conformance-to-use assessments; then, fitting service engineering, grounded on ambient-intelligence, comes out as winning opportunity;
- from the product disposal: today, most of durables, and in a short future, the whole consumables need to fall within suppliers' responsibility, under to the free-take-back scheme, aiming at reverse logistics treatments for resource recovering and dump avoiding.

FIG. 11 EXAMPLE CLUES FOR MANUFACTURER/SUPPLIER LIABILITY

When dealing with the manufacturer/supplier responsibility, the extant depletion/contamination refund takes into account a few chances, Fig. 12, each one affected by induced drawbacks.

For the policy makers, the service economy, basically, requires the bottom-up qualification of the front-end 'sustainable corporations'. The standard knowledge includes the above listed prerequisites and options, from the 2P2E design, to the purposefully developed service-oriented computer aids.

- tax on virgin materials or subsidies on recycled stuffs, paid at provisioning or at recovery (possible distortions on primary/secondary materials market, unless global legal metrology prices are stated);
- landfill charges, paid for waste dumping (possible negative effect: illegal dump);
- recycling fee/credit, paid by artefacts buyers and transferred to subsidise recycling (possibly profit for reverse logistics operators);
- deposit-refund, paid by first buyers and returned to the last owners at dismissal (possible negative effect: illegal trade of end-of-life items);
- free-take-back, included in the price of new artefacts and used by producers to subsidise recycling (possible profit for monopolistic manufacturers).

FIG. 12 EXAMPLE REPAYMENTS OF RESOURCE WITHDRAWALS

The ELV and WEEE demands require throughout changes of the industry surroundings, with huge fallouts in research and development structures and in market regulation, such as the ones listed in the Fig. 13.

- direct investments by manufacturers, to switch product competition into recoverability figures;
- restructuring the reverse logistics business, into high-tech efficient reuse/recycling companies;
- creation of producers/ dismantlers/ recyclers clusters, with collaborative networked-organisations;
- growth of certifying bodies, to manage the economic instruments, under the EU mandatory acts.

FIG. 13 EXAMPLE FALLOUTS OF RECOVERY/RECLAMATION DUTIES

Concluding Comments, Future Plans

The 'sustainable growth' is bet, more than certitude. In the paper, the backdrop looming threats were recalled, not investigated, since their general features were well known outcomes of the 'ecology' globalisation, already well assessed by recent examinations. Even if the present survey, typically, limited to engineering statements, the 'eco-service' prospects were viewed in the more enthralling context of the 'cognitive revolution', which is necessary, once recognised the 'industrial revolution' drawbacks. Then, to figure out general rules answering the 'sustainable growth' demands, a bird-eye analysis of the ground-breaking variations to come was, initially, given, to provide

evidence of the main standard knowledge, requested by policy makers and research leaders. The hints were combined into huge listing of 'suggested readings', knowingly inserted, to show that today mankind is at a civilisation turning point, as e.g. (Kupchan, 2012), (Manhbubani K., 2013), (Michelini, 2009), (Schaltegger S., 2006), (Schmidt, 2013), (Stannard R., 2010), (Stern N., 2009), (Wilson E.O., 2012), (Zaring D., 2009).

The investigation purposes were to, thus, exploit the general ecology demands, to make understanding that inclusive changeovers are compulsory, once looking at mitigating the over-depletion/contamination outcomes, by the lifecycle reclamation of the on-going processes, through suited service allocations. The wide-ranging goals of the study defined the main trends, Fig. 14, of the human civilisation adventure, to elucidate the in-progress value added deployments.

the oddity of the adventure of men, trusting their planning and proficiency talent;
 considerations on the backdrop: science issues, picturing our earth and universe;
 considerations on the actors: civilisation endings, rooted in intelligence originality;
 survey of the mainly social advancements, grounded also on history achievements;
 survey of the basic politics and economics frameworks, to derive continuity hints;
 the awkward trial of sustainability prerequisites for a hoped cognitive revolution.

FIG. 14 MAIN PECULIARITIES OF THE MEN ADVENTURE

At the special purpose engineering concern, the servicing changeover is noteworthy innovating opportunity. The integrated 2P2E deployment permits to extend the supply chain coverage, aiming at consistent delivering 'products-services', under the unified responsibility of companies or clusters of facilities which exploit net infrastructures and 'virtual' organisations, to create the effective service-provider, whenever given business opportunities establish, according to voluntary agreements or to mandatory targets. The prospected research activity is necessary prerequisite of the coming manufacture market; referring to ICT tools, including a few specific chances, Fig. 15, supplied by suited computer aids.

These example technical aids are the issue of trans-disciplinary advances, when the entrepreneurial business can incorporate the fitting net concern technologies, addressing the new developments

towards exploiting the facility and function integration, into extended/virtual enterprise sceneries. The lifecycle eco-service comes out to be business opportunity, rooted in compulsory 'lawfulness' schemes, yet, efficiently buttressed by the existing net concern infrastructures. This survey helps sketching the prospects at an engineering standpoint; the socio-political discussion of the topics requires further deepening: the 'suggested reading' list shows that wide diagnoses and projections are already available.

- the information architecture for data exchange, access handling, security management, contingency ruling, etc., with operation agents (local units, network servers, archives managers, search engines, security tutors, etc.) and distributed services (access, messaging, etc.) with storages (catalogues, databases, etc.);
- the support mechanisms and tools for the net concern overseeing, as, by itself, the net is not enough, and it requires the interoperability, the resources integration and co-ordination, the performance monitoring and evaluation, etc., to feed the stakeholders with the pertinent operation visibility;
- the lifecycle transparency of the dynamic 'virtual' corporation, covering the phases of creation, operation and dissolution, so that the market of facilities/functions, through the differentiated offer/demand partners, keeps leading role in the negotiation of optimally suited arrangements.

FIG. 15 EXAMPLE OPTIONS ENABLED BY ICT TOOLS

This paper contains several engineering, human and philosophical hints and ideas, however some kind of methodology, quantification, measurements and calculation possibilities are still open and need further studies to properly evaluate behaviours and situations and relationships.

References & Suggested Readings

- Abele E., Anderl R., Birkofer H, "Environmentally-friendly product development: methods and tools", Springer, London, 2005.
- Agar J, "Science in the twentieth century and beyond", Polity, London, 2012.
- Antonelli C, "The economics of innovation: critical concepts in economics", Rutledge, New York, 2008.
- Baskin A. B., Kovács G. L., Jacucci G., Eds., "Co-operative knowledge processing for engineering design", Kluwer Academic Pub., Norwell, 1999.
- Bhide A., "The venturesome economy: how innovation sustains prosperity in a more connected world", Princeton Uni. Press, Princeton, 2008,
- Carlson R., "Biology is technology: the promise, peril and new business of engineering life", Harvard Uni. Press, Cambridge, 2010.
- Charbonneau S., "Droit communautaire de l'environnement" L' Harmattan, Paris, 2006.
- Dym C. L., Little P., "Engineering design: a project-based introduction", J. Wiley, Hoboken, 2010.
- Friedman T. L., "Hot, flat and crowded: why we need a green revolution and how it can renew America", Farrar, Straus & Giroux, New York, 2009..
- Fukuyama F., "The origin of political orders: from prehuman times to the French Revolution", Straus & Giroux, New York, 2011.
- Guo C., Eds., "Ecosystem ecology research trends", Nova Sci. Pub., New York.
- Hawken P., Lovins A. B., Hunter Lovins L., "Natural capitalism: creating the next industrial revolution", Little, Brown & Co., Boston, 1999.
- Hilaire-Pérez L., Garçon A. F., Eds., "Le chemin de la nouveauté: innover et inventer au regard de l'histoire", Cth's Histoire 9, Paris, 2003.
- Hodgson P.E., "Energy: environment and climate change", Imperial College Pub., London, 2010.
- Kupchan C., "No one's world: the west, the rising rest and the coming global turn", Oxford Uni. Press, N.Y. 2012.
- Lacy S., "Brilliant, crazy and cocky", John Wiley & Sons, Hoboken, 2011.
- Lafley A.G., Martin R., "Playing to win: how strategy works", Harvard Business Review Press, Boston, 2013.
- Lin J. Y., "The quest for prosperity: how developing economies can take off", Princeton Uni. Press, London, 2012
- Low L, Ed., "Developmental states: relevancy, redundancy or reconfiguration?", Nova Sci. Pub., New York, 2004
- Macarthur D., DeCaro M., Eds., "Naturalism and normativity", Columbia Uni. Press, New York. 2010
- Manhubani K., "The great convergence: Asia, the West and the logic of one world", Public Affair, N. Y. 2013
- Marsh P., "The new industrial revolution: consumers globalisation and mass production end", Yale Uni. Press, New Haven, 2012.

- Michelini R. C., Ed., "Automation and resources' utilisation", XIV BIAS, FAST, Milano, 1976.
- Michelini R. C., Razzoli R. P., "Affidabilità e sicurezzadelprodottointindustriale: progettazioneintegrata per lo svilupposostenibile" Tecniche Nuove, Milano, 2000.
- Michelini R. C., "Knowledge entrepreneurship and sustainable growth", Nova Sci. Pub., New York, 2008.
- Michelini R. C., "Robot age knowledge changeover", Nova Sci. Pub., New York, 2009.
- Michelini R. C., "Knowledge society engineering: a sustainable growth pledge", Nova Sci. Pub., New York, 2011.
- Michelini R. C., "Society progress evolution: sustainability and responsiveness", Nova Science Pub., N. Y., 2012.
- Olhagher J., Persson F., Eds., "Advances in production management systems", Springer, Boston, 2007.
- Otto K. N., Wood K. L., "Product design techniques in reverse engineering and new product development", Prentice Hall, Upper Saddle River, 2001.
- Phahalad C. K., Krishnan M., "The new age of innovation: driving co-created value through global networks", McGraw Hill, New York, 2008.
- Preston R., "How do we fix this mess? the economic price of having it all and the route to lasting prosperity", Hodder& Stoughton, London, 2012.
- Pries K. H., Quigley J. M., "Project management of complex embedded systems: ensuring product integrity and program quality", CRC Press, Boca Raton, 2009.
- Putnik G. D., Cunha M.M., Eds., "Knowledge and technology management in virtual organisations integration: issues, trends, opportunities and solutions, IDEA Group Pub., IGI Press, Hershey, 2007.
- Schaltegger S., Wagner M., "Management the business case for sustainability", Greenleaf Pub., Sheffield, 2006.
- Schmidt E., Cohen J., "The new digital age: reshaping the future of people, nations and business, Knopf, New York, 2013.
- Stannard R., "The end of discovery: are we approaching the boundaries of the knowable?", Oxford Uni. Press, New York, 2010.
- Stark J., "Product life-cycle management: paradigm for 21st century product realisation", Springer, London, 2005.
- Stern N., "The global deal: climate change and the creation of a new era of progress and prosperity", The Bodley Head, London, 2009.
- Suh S., Heijungs R., "The computational structure of lifecycle assessment", Kluwer Acad. Pub., Dordrecht, 2002.
- Targowski A., "Information technology and societal development", IGI Pub., Hershey, 2008.
- Teuteberg F., Gomez J. M., Eds., "Corporate environmental management information systems", IGI, Business Science Reference, Hershey, 2010.
- Thursby M., Libecap G. D., Eds., "Technological innovation: generating economic return", Emerald Book, Bingley, 2008.
- Tinaglia I., Szeremeta J., "Understanding knowledge societies", United Nation Pub., New York
- Tischner U., Charter M., "Sustainable solutions: developing products-services for the future", Greenleaf Pub., Sheffield, 2001.
- Troccoli A., Ed., 2009, Management of weather and climate risk in the energy industry, Springer, London, 2009.
- Van Johnston R., "Entrepreneurial management and public policy", Nova Sci. Pub., New York, 2010.
- Vergne P., Durand R., "The pirate organisation: lessons from the fringes of capitalism", Harvard Business Review Press, Boston, 2012.
- Victor D., "Global warming gridlock: creating more effective strategies for protecting the planet", Cambridge Uni. Press, New York., 2011.
- Vinig G. T., van der Woort R. C. W., Burgelman R.A., Chesbrough H., Eds., "The emergence of the entrepreneurial economics", Emerald Book, Bingley, 2005.
- Warren F. R., "Practice of sustainable community development: a participatory framework for change", Springer, Berlin, 2012.
- Wassermann O., "The intelligent organisation: winning the global competition with supply chain idea", Springer, Berlin, 2001.
- Wheeler L. T., Lawrence C. S. Eds., "Climate change disclosure and financial risk: merits and concerns", Nova Sci. Pub., New York, 2012.
- Wilkinson R., Picket K., "The sprit level: why more equal societies almost always do better", Allen Lane, London, 2009.

- Wilson Wickramasinghe N, vonLubitz D., "Knowledge based enterprise: theories and fundamentals", Idea Group Pub., Hershey, 2007.
- Wilson E. O., "The social conquest of the earth", Norton, New York, 2012.
- Wills B., "Green intensions: creating a green value stream to compete and win", CRC, Boca Raton, 2009.
- Wohlgemuth V., Page B., Voight K., Eds., "Environmental informatics and industrial eco-protection: concepts, methods and tools", Shaker, Aachen, 2009.
- Woods D. D., Hollnagel E., "Joint cognitive systems: patterns in cognitive systems engineering", CRC, Boca Raton, 2006.
- Xie M, "Fundamental of robotics: linking perception to action", Imperial College Press, London, 2012.
- Yergin D., "The quest: energy, security & the remaking of the modern world", Penguin, London, 2011.
- Zaring D., Coglianese C., Finkel A.M., 2009, Import safety: governance in the global economy, Uni. Pennsylvania Press, Philadelphia, 2009.
- Zarnkow R., Brenner W, Pilgram U., "Integrated information management: applying successful industrial concepts in information technology", Springer, London, 2006.
- Zatzman G., Islam R., Eds., "Economics of intangibles", Nova Sci. Pub., New York, 2007.
- Zhuge H., "The knowledge grid: toward cyber-society", World Sci. Pub., Singapore, 2012.
- Zuber-Skerrit O., "Action research for change and development", Grower Pub., Aldershot, 1991.
- Zurawski R. "Integration technologies for industrial automated systems", CRC, Boca Raton, 2007.

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